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INTRODUCTION TO THE PMR REAL TIME DATA PROCESSING SYSTEM

Paradyn Division, Dynalectron Corporation
and Test Data Division
Range Operations Department
PACIFIC MISSILE RANGE

TEST DATA DIVISION
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Copies are available on request from the Test Data Division, Range Operations Department, Code 3280, Pacific Missile Range.

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ABSTRACT

This overview of the PMR Real Time Data Processing System explains the scope and function of the system at its present stage of development. The document includes (1) a block diagram of the flow of information to the PMR Digital Data System, (2) the programing requirement for the Larey-LeRoy Computer Buffer System for the IBM 7090, (3) a list of people who may be contacted for additional information on the individual subsystems, and (4) a brief description of the following: (a) AN/FPS-16 radar, (b) Missile Tracking Radar, (c) Cotar, (d) Digital Distribution Unit, (e) Speed Changer and Buffer, (f) Collins TE-206 Kineplex Transmitter and Receiver, (g) Data Multiplexing Synchronizer, (h) MicroSADIC and DOLAR Systems, (i) Teletype, (j) Paper Tape, (k) Larey-LeRoy Computer Buffer System, (l) Real Time Input Record.

FOREWORD

This is a manual to guide new programers in the use of the Pacific Missile Range Real Time Data Processing System. It is divided into five parts: (1) the entire live real time system, (2) the equipment outside Building 50, (3) the equipment in Building 50 and adjacent to the computer, (4) an explanation of the computer input format, (5) authorities on the individual systems.

The equipment is discussed with emphasis on its function and with only brief attention to how it works. For the benefit of those who may wish greater detail a list of technically qualified persons at the PMR who are able to discuss parts of the system at length is included.

The report was initiated on the instigation of Mr. Lando Goertzen, Test Data Division real time programer. Contributions to this document are many. Section 3.5, the Larey-LeRoy Computer Buffer System, was taken, with modification and additions, from the "Programing Requirements for the Point Mugu Buffer for the IBM 7090" which was written by Messrs. B. Larey and C. LeRoy, of the PMR Range Development Department. Also, Mr. Larey was the source of information for the section on Computer Output System. The sources of information for the MicroSADIC and DOLAR Systems were Messrs. J. Chapman, and J. Kendrick of the PMR Range Operations Department. Those who contributed information on the Data Multiplexing Synchronizer were Messrs. A. James of the PMR Range Operations and P. Rotshek of Cubic Corporation. Section 4 was taken with modifications from Land-Air Report No. 26, "Computer Programing for Real Time Impact Prediction and Destruct Control." The document was compiled by Mr. Richard Johnson and was edited and prepared for publication by Mr. T. Wakai, both of the Paradyn Division, Dynalectron Corporation.

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LIST OF ILLUSTRANTIONS

1 INTRODUCTION

The PMR real time data system grew to take over certain operation controls as the demand for speed outpaced human reaction time. Initially the system consisted of two radars on a mountain top, outputting through two miles of telephone line to a large scale computer that was programed to predict missile impact location. Because that primitive system was successful, operations could be conducted safely.

Demands on the system increased, however, with the increase in missile accelerations. New outputs were required. More criteria were introduced for judging the safety of missile flight operations. More inputs were added -- inputs from instruments dispersed over a greater area and tied to not one, but two computing sites via the microwave link.

Todays system as a whole is illustrated in Figure 1 where the brain is clearly the large scale IBM 7090 computer. Of no less importance, however, is the heart of the system, which is the computer input buffer and the subject of this manual.

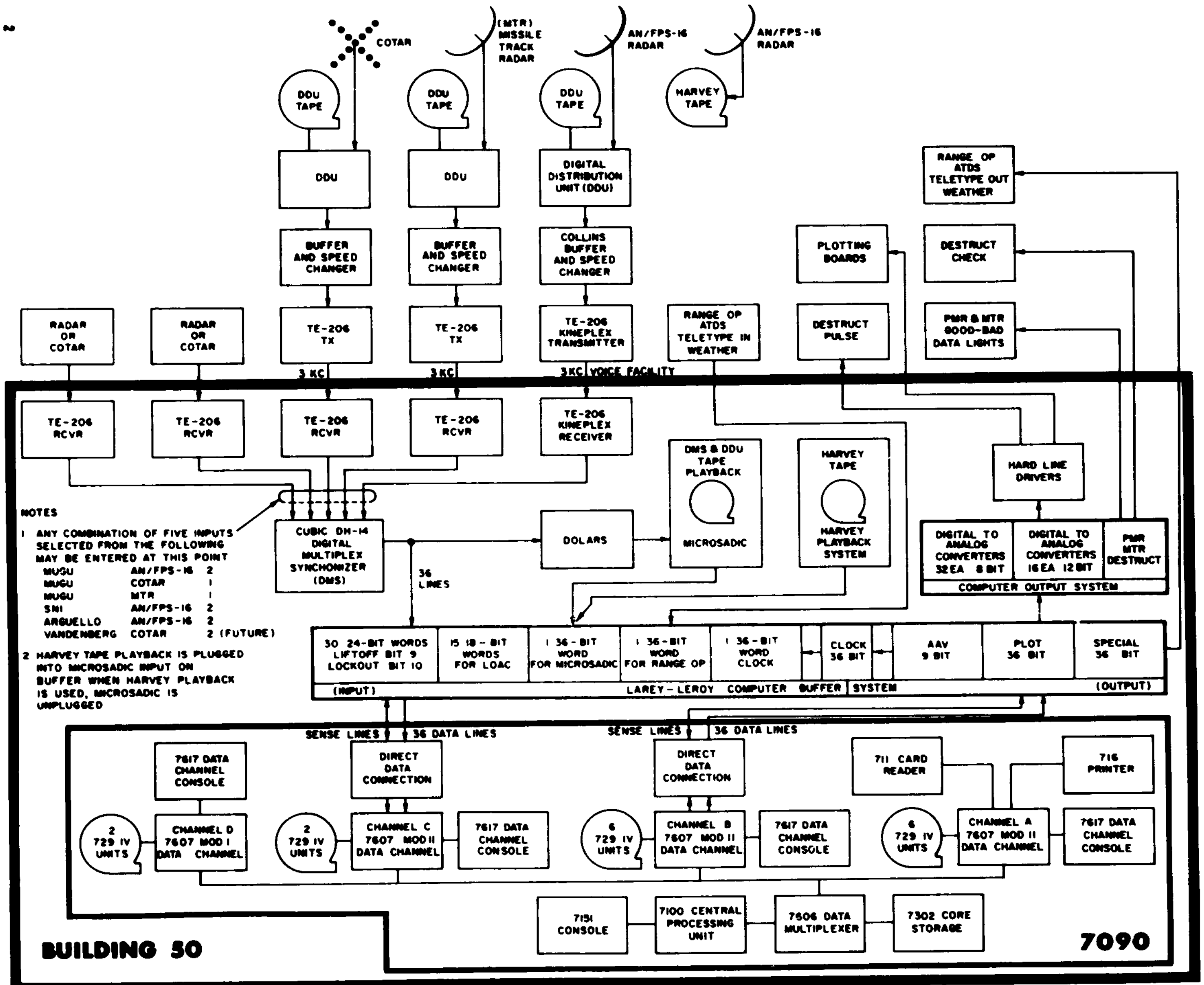

FIGURE 1. PMR DIGITAL DATA SYSTEM

2 EXTERNAL SYSTEM

The Pacific Missile Range (PMR) Data System has fourteen input sources. Ten of these are AN/FPS-16 radars, three are Cotars, and one is a Missile Tracking Radar (MTR). These instruments are distributed as follows: 4 FPS-16 radars, one MTR, and one Cotar at Point Mugu; 3 FPS-16's at San Nicolas Island; 2 FPS-16's at Point Arguello; and 2 Cotars at Vandenberg Air Force Base; 1 FPS-16 at Point Pillar.

2.1 AN/FPS-16 Radar

The AN/FPS-16 radar is the first link in the input chain at the Pacific Missile Range. It is a "C" Band, Beacon or Skin Track Radar. It tracks an aircraft or missile by the reflection of the signal from the metallic surface of the craft. The ranges at which this radar can track are 200, 500, or 5000 miles, depending on the equipment at each site. The FPS-16 has a horizontal search of 360° and a vertical search of 180°+. It outputs range, azimuth, and elevation to a Digital Distribution Unit (DDU) at each site.

2.2 Missile Tracking Radar (MTR)

The MTR (Manufactured by Western Electric) is controlled exclusively by the NIKE-ZEUS facilities at Point Mugu. It is a special purpose radar used for tracking and guidance of the NIKE-ZEUS only, so its operational capabilities will not be discussed here.

2.3 Cotar

The Cotar is a passive, angular measuring instrument that tracks a beacon signal. However, two Cotars are necessary to provide directional information to compute the exact location of an aircraft or missile at any given time. A Cotar tracks a beacon transmitter on one of 27 possible preassigned frequencies. The horizontal coverage of the Cotar is 360° and the vertical coverage is 1.5° to 75°. The Cubic Corporation, which manufactures the Cotar, claims that it has an accuracy of 50 parts per million. The output of the Cotar to the DDU is in a digital format.

2.4 Digital Distribution Unit (DDU)

The Cubic DH-10 DDU extracts digital polar data from the AN/FPS-16, Cotar, or MTR and converts them into suitable format for recording and Kineplex transmission between sites. Data may be extracted from the radar or Cotar at rates of 40, 20 or 10 samples per second, with each sample containing 120 bits. At 40 samples per second, only alternate samples are actually transmitted. The DDU includes a magnetic tape handler which records the data for postflight analysis. While recording, the DDU can accept data at the rate of 40 samples per second; however, for entry into

the computer,this recording is played back at half speed or 20 samples per second. The DDU provides interrogation pulses to the radar or Cotar in synchronism with range timing to sample the position of the radar or Cotar code wheels, and accepts radar or Cotar data in the form of slant range, azimuth and elevation. The DDU also generates timing for recording and synchronization and the necessary redundancy and identification information.

2.5 Speed Changer and Buffer-Transmit

The Collins Buffer and Speed Changer in the TE-206 transmitter accepts radar or Cotar digital data on four lines at a 1200 pps rate during real time transmission from the DDU. Here the data is stored in a magnetic core memory for subsequent transfer into the Kineplex Transmitter or Kineplex data rates.

2.6 Collins TE-206 Kineplex Transmitter

The Collins TE-206 Transmitter accepts digital data at a rate of 2400 bits per second. It phase modulates 4 tones (21-24 kc), mixes these tones to produce a composite tone, and beats this tone down to a 3 kc band width audio signal which may be transmitted over telephone wires or a microwave channel to the Collins TE-206 Receiver.

2.7 Collins TE-206 Kineplex Receiver

The Collins TE-206 Kineplex Receiver receives the 3 kc band width composite audio signal from the Transmitter, hetrodynes it back to 21-24 kc tones, extracts the phase modulation from these 4 tones, and generates digital data from the phase shift information.

3 INTERNAL EQUIPMENT

3.1 The Data Multiplexing Synchronizer (DMS)

The DMS receives digital words simultaneously from one to six Kineplex receivers in the formats shown in Figures 2, 3, and 4 and converts these words into the buffer input formats also shown. The converted data is then sent to the Point Mugu Computer Input Buffer for entry into the computer. The first word of each sample from two or more sources must arrive within an interval of 3.3 milliseconds. Otherwise, lockout occurs and the DMS refuses to accept information from any source during this sample. Because of this lockout, the feasibility of rejecting the information from only the site reporting a difference in time and retaining the information from the other sites is being studied. The DMS is designed to receive and process information at the rates of 10 or 20 samples per second; other rates cause malfunction. Ten samples per second input is normally used during live runs, except that 20 samples per second input is used for solid fuel missiles. The DMS can output information to the MicroSADIC, to the buffer, or to both simultaneously. Since the DMS can handle live inputs from only 6 sources, it is responsible for limiting the number of live inputs to six.

3.2 MicroSADIC and DOLAR System

Although these systems are basically one, because of their unique functions they are referred to as two systems. The DOLAR portion can do one thing only: record radar data from the DMS onto a digital magnetic tape. This tape is then placed on the computer for processing. The MicroSADIC portion, which basically handles telemetry data tapes, reads an analog tape and converts it to digital format. This output may go to a digital recorder, to a one-word MicroSADIC buffer for insertion into the Point Mugu Computer Input Buffer, or to both simultaneously. This digital tape can be read back into the MicroSADIC and through the one-word MicroSADIC buffer for entry to the Point Mugu buffer. Also, this tape may be processed directly by the computer. Whenever the MicroSADIC generates a tape, it writes a low density tape, unlike the computer, which normally writes high density tapes.

3.3 Teletype

The information flow is as follows: The input can be selected from one of several sources, and the basic teletype information is transmitted to Building 50 via radio frequency, or hard lines, or both. Upon reaching Building 50 this basic information can be sent to the computer in teletype format, or it can be run through a converter which changes basic teletype output to a computer format. This digital information is then read into the buffer for entry to the computer. The output from the computer for the teletype is just the reverse of its input: from the computer to the buffer, then from the buffer to the converter, where digital information is converted to a form suitable for teletype transmission.

Odd groups	30	29			26	25			22	21			18	17			14	13			10	9			6	5			2	1
Even groups			28	27			24	23			20	19			16	15			12	11			8	7			4	3		
CHAN. 1 DATA	0	0	EØR X	EØR X	EØR X	0	C4	C8	0	C15	C19	0	B4	B8	0	B15	B19	0	KC4	KC8	0	IC1	IC5	0	T4	T8	0	T15	TV4	SØR X
CHAN. 2 DATA	0	0	P1-E	P1-Ø	P2-E	P2-Ø	C3	C7	C11	C14	C18	I1-2	B3	B7	B11	B14	B18	I0-2	KC3	KC7	KR2	KR5	IC4	0	T3	T7	T11	T14	TV3	TV7
CHAN. 3 DATA	0	0	P3-E	I3-2	P3-Ø	I2-2	C2	C6	C10	C13	C17	I1-1	B2	B6	B10	B13	B17	I0-1	KC2	KC6	KR1	KR4	IC3	I0-3	T2	T6	T10	T13	TV2	TV6
CHAN. 4 DATA	0	0	P4-E	T16	P4-Ø	I2-1	C1	C5	C9	C12	C16	I2-3	B1	B5	B9	B12	B16	I1-2	KC1	KC5	KC9	KR3	IC2	IC6	T1	T5	T9	T12	TV1	TV5
CHAN. 5 DATA	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C
CHAN. 6 DATA	0	0	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
	5th WORD-PARITY						4th WORD-DATA III						3rd WORD-DATA II						2nd WORD-DATA I						1st WORD-TIME					
	ONE RECORD																													

DDU TO DMS FORMAT

BIT POSITION	1 THROUGH 11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
2nd WORD-TIME	ALL ZEROS	0	SØR X	TV7	TV6	TV5	TV4	TV3	TV2	TV1	T15	T14	T13	T12	T11	T10	T9	T8	T7	T6	T5	T4	T3	T2	T1
8th WORD-DATA I	ALL ZEROS	0	0	Q	I0-3	IC6	IC5	IC4	IC3	IC2	IC1	KR5	KR4	KR3	KR2	KR1	KC9	KC8	KC7	KC6	KC5	KC4	KC3	KC2	KC1
14th WORD-DATA II	ALL ZEROS	0	0	I0-2	I0-1	I1-3	B19	B18	B17	B16	B15	B14	B13	B12	B11	B10	B9	B8	B7	B6	B5	B4	B3	B2	B1
20th WORD-DATA III	ALL ZEROS	0	0	I1-2	I1-1	I2-3	C19	C18	C17	C16	C15	C14	C13	C12	C11	C10	C9	C8	C7	C6	C5	C4	C3	C2	C1
26th WORD-PARITY	ALL ZEROS	PBD	0	P2-Ø	I2-2	I2-1	EØR X	P2-E	P3-Ø	P4-Ø	EØR X	P1-Ø	I3-2	T16	P1-E	P3-E	P4-E	0	0	0	0	X	TV7	TV6	TV5

DMS TO COMPUTER FORMAT

~ LEGEND ~

Q – DATA QUALITY
I_{PN} – I D. OCTAL CODE
B_N – DATA PARAMETER 1 (COS-B)
C_N – DATA PARAMETER 2 (COS-A)
KC_N – CALIBRATION
KR_N – FREQ. RATIO SELECTOR

P – LATERAL PARITY
T_N – TIME WORD PARAMETER
TV_N – TIME VERNIER COUNT
X – CONSTANT "ONE" BITS
P_NE – LONGITUDINAL PARITY, EVEN
$P_NØ$ – LONGITUDINAL PARITY, ODD

0 – CONSTANT ZERO BITS
SOR – START OF RECORD
EOR – END OF RECORD
PBD – BAD PARITY BIT

FIGURE 2. COTAR DATA FORMAT

30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	
30	29			26	25			22	21			18	17			14	13			10	9			6	5			2	1	ODD GROUPS
		28	27			24	23			20	19			16	15			12	11			8	7			4	3			EVEN GROUPS
0	0	EØR X	EØR X	EØR X	0	C4	C8	0	C15	I2-3	0	B4	B8	0	B15	B19	0	A4	A8	0	A15	IO-1	0	T4	T8	0	T15	TV4	SØR X	CHAN. 1 DATA
0	0	P1-E	P1-Ø	P2-E	P2-Ø	C3	C7	C11	C14	C18	I1-3	B3	B7	B11	B14	B18	B22	A3	A7	A11	A14	A18	Q	T3	T7	T11	T14	TV3	TV7	CHAN. 2 DATA
0	0	P3-E	B23	P3-Ø	I3-2	C2	C6	C10	C13	C17	I1-2	B2	B6	B10	B13	B17	B21	A2	A6	A10	A13	A17	IO-3	T2	T6	T10	T13	TV2	TV6	CHAN. 3 DATA
0	0	P4-E	T16	P4-Ø	I2-1	C1	C5	C9	C12	C16	I1-1	B1	B5	B9	B12	B16	B20	A1	A5	A9	A12	A16	IO-2	T1	T5	T9	T12	TV1	TV5	CHAN. 4 DATA
C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	CHAN. 5 CLOCK
0	0	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	CHAN. 6 PARITY
← 5th WORD-PARITY →						← 4th WORD-DATA III →						← 3rd WORD-DATA II →						← 2nd WORD-DATA I →						← 1st WORD-TIME →						
← ONE RECORD →																														

DDU TO DMS FORMAT

1 THROUGH 11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	BIT POSITION
ALL ZEROS	0	SØR X	TV7	TV6	TV5	TV4	TV3	TV2	TV1	T15	T14	T13	T12	T11	T10	T9	T8	T7	T6	T5	T4	T3	T2	T1	1st WORD-TIME
ALL ZEROS	0	0	Q	IO-3	IO-2	IO-1	A18	A17	A16	A15	A14	A13	A12	A11	A10	A9	A8	A7	A6	A5	A4	A3	A2	A1	7th WORD-DATA I
ALL ZEROS	0	0	B22	B21	B20	B19	B18	B17	B16	B15	B14	B13	B12	B11	B10	B9	B8	B7	B6	B5	B4	B3	B2	B1	13th WORD-DATA II
ALL ZEROS	0	0	I1-3	I1-2	I1-1	I2-3	C18	C17	C16	C15	C14	C13	C12	C11	C10	C9	C8	C7	C6	C5	C4	C3	C2	C1	19th WORD-DATA III
ALL ZEROS	PBD	0	P2-Ø	I2-2	I2-1	EØR X	P2-E	P3-Ø	P4-Ø	EØR X	P1-Ø	B23	T16	P1-E	P3-E	P4-E	0	0	0	0	X	TV7	TV6	TV5	25th WORD-PARITY

DMS TO COMPUTER FORMAT

LEGEND

- Q – DATA QUALITY
- I_{PN} – I D. OCTAL CODE
- A_N – DATA PARAMETER 1 (EL)
- B_N – DATA PARAMETER 2 (RANGE)
- C_N – DATA PARAMETER 3 (AZ)
- P – LATERAL PARITY
- T_N – TIME WORD PARAMETER
- TV_N – TIME VERNIER COUNT
- X – CONSTANT "ONE" BITS
- P_NE – LONGITUDINAL PARITY, EVEN
- $P_NØ$ – LONGITUDINAL PARITY, ODD
- 0 – CONSTANT ZERO BITS
- SOR – START OF RECORD
- EOR – END OF RECORD
- PBD – BAD PARITY BIT

FIGURE 3. AN/FPS RADAR DATA FORMAT

30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	
30	29			26	25			22	21			18	17			14	13			10	9			6	5			2	1	ODD GROUPS
		28	27			24	23			20	19			16	15			12	11			8	7			4	3			EVEN GROUPS
0	0	EØR X	EØR X	EØR X	0	C4	C8	0	C15	I2-3	0	B4	B8	0	B15	B19	0	A4	A8	0	A15	IO-1	0	T4	T8	0	T15	TV4	SØR X	CHAN. 1 DATA
0	0	PI-E	PI-Ø	P2-E	P2-Ø	C3	C7	C11	C14	C18	I1-3	B3	B7	B11	B14	B18	IES	A3	A7	A11	A14	A18	Q	T3	T7	T11	T14	TV3	TV7	CHAN. 2 DATA
0	0	P3-E	I3-2	P3-Ø	I3-2	C2	C6	C10	C13	C17	I1-2	B2	B6	B10	B13	B17	B21	A2	A6	A10	A13	A17	IO-3	T2	T6	T10	T13	TV2	TV6	CHAN. 3 DATA
0	0	P4-E	T16	P4-Ø	I2-1	C1	C5	C9	C12	C16	I1-1	B1	B5	B9	B12	B16	B20	A1	A5	A9	A12	A16	IO-2	T1	T5	T9	T12	TV1	TV5	CHAN. 4 DATA
C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	CHAN. 5 CLOCK
0	0	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	CHAN. 6 PARITY
5th WORD-PARITY						4th WORD-DATA III						3rd WORD-DATA II						2nd WORD-DATA I						1st WORD-TIME						
ONE RECORD																														

DDU TO DMS FORMAT

1 THROUGH 11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	BIT POSITION
ALL ZEROS	0	SØR X	TV7	TV6	TV5	TV4	TV3	TV2	TV1	T15	T14	T13	T12	T11	T10	T9	T8	T7	T6	T5	T4	T3	T2	T1	3rd WORD-TIME
ALL ZEROS	0	0	Q	IO-3	IO-2	IO-1	A18	A17	A16	A15	A14	A13	A12	A11	A10	A9	A8	A7	A6	A5	A4	A3	A2	A1	9th WORD-DATA I
ALL ZEROS	0	0	IES	B21	B20	B19	B18	B17	B16	B15	B14	B13	B12	B11	B10	B9	B8	B7	B6	B5	B4	B3	B2	B1	15th WORD-DATA II
ALL ZEROS	0	0	I1-3	I1-2	I1-1	I2-3	C18	C17	C16	C15	C14	C13	C12	C11	C10	C9	C8	C7	C6	C5	C4	C3	C2	C1	21st WORD-DATA III
ALL ZEROS	PBD	0	P2-Ø	I2-2	I2-1	EØR X	P2-E	P3-Ø	P4-Ø	EØR X	PI-Ø	I3-2	T16	PI-E	P3-E	P4-E	0	0	0	0	X	TV7	TV6	TV5	27th WORD-PARITY

DMS TO COMPUTER FORMAT

LEGEND

Q – DATA QUALITY
IPN – I.D. OCTAL CODE
AN – DATA PARAMETER 1 (EL)
BN – DATA PARAMETER 2 (RANGE)
CN – DATA PARAMETER 3 (AZ)
P – LATERAL PARITY
TN – TIME WORD PARAMETER
TVN – TIME VERNIER COUNT
X – CONSTANT "ONE" BITS
PNE – LONGITUDINAL PARITY, EVEN
PNØ – LONGITUDINAL PARITY, ODD
O – CONSTANT ZERO BITS
SØR – START OF RECORD
EØR – END OF RECORD
PBD – BAD PARITY BIT
IES – NEW DATA BIT

FIGURE 4. MISSILE TRACKING RADAR DATA FORMAT

3.4 Punched Paper Tape

The processing of paper tape input is similar to that of the teletype input. However, a paper tape reader is used instead of a teletype input.

3.5 Larey-LeRoy Computer Buffer System

3.5.1 The Point Mugu Buffer for the IBM 7090 was designed and developed by Bert W. Larey and Charles W. LeRoy and was built by the Pulse and Digital Branch of the Range Development Department of PMR at Point Mugu. Being a two stage unit, the buffer permits the transfer of data into and out of the central processing unit. Of all the real time equipment at PMR, this buffer is used more than any other equipment in a system capacity since it provides the connecting link between all peripheral input and output equipment and the computer. This system has been provided to supply level changing and intermediate signal storage between the computer and other data handling systems. The buffer system will provide the following signal storage:

1. Thirty 24 bit words for DMS (IDTS System).
2. Fifteen 18 bit words for LOAC (aircraft vectoring data input).
3. One 36 bit word for the MicroSADIC.
4. One 36 bit word for Range Operations data handling systems.
5. One 36 bit word for the Clock systems.
6. The output section does not contain any data storage but utilizes the input registers of the Data Output System. It transfers 36 bit words to the Plot and Special systems, 35 bits to the Clock, and 9 bits to the AAV system.

3.5.2 Reading Data into the Computer

The buffer will continuously accept data from the Data Systems at their normal rates of transmission.

When the Input Buffer has data to transmit to the computer, the following sequence takes place:

1. The buffer will raise the sense line or lines associated with the data source.
2. An interrupt signal will be sent to the computer, if desired.
3. The sense lines will remain up until
    a) the computer signifies acceptance of the data by returning a sense pulse and a read select to the buffer,
    b) the computer informs the buffer that the data is not wanted by sending sense pulse 10 (data not wanted), or
    c) the data source transmits new data to the buffer, erasing the old data in its memory.

The buffer will assign priorities to the input data in the following order:

1. Clock overflow
2. DMS
3. LOAC
4. MicroSADIC
5. R. O. Input

If two or more data sources are loaded at the same time the one with the highest priority will be recognized first. If the data has been transmitted to the computer or if the computer signals that the data is not wanted, the next highest input channel will be recognized.

3.5.3 Limitations

The input buffer will not generate interrupts more frequently than at 90 microsecond intervals. Also, no interrupt will be generated while data is being transmitted between the buffer and the computer while the computer read select is high. This means that if the DMS and the MicroSADIC registers are loaded simultaneously, the MicroSADIC data will be delayed at least 900 microseconds while the DMS data is being read into the computer. The computer will not accept interrupts while operating "in manual", and will not accept them in any cycle time other than "I".

If the computer operates under record control, no interrupts will be sent to the computer while the read select signal is high. In this mode the maximum data transfer rate of the buffer will be approximately one word every 30 microseconds.

The initiation of data transfer from the buffer to the computer requires only a read select (ROS 1696), channel ready read (RCHD), and an appropriate sense pulse (PSLB) from the computer to tell the buffer which data to transfer out. The buffer will supply the required demand pulses as soon as possible. Because of the serial storage used in the buffer, access time to the initial DMS or LOAC words will vary between 1 and 180 microseconds. Succeeding DMS or LOAC words in the same record will follow at thirty microsecond intervals until the complete record has been read out. Other types of data will be transferred within a few microseconds after receipt of a channel ready read from the computer. While inputting information to the buffer at 20 samples per second, 49 milliseconds are available between inputs to process the data before the next record is transferred. However, programers should try to keep this processing time down to 44 milliseconds between inputs when operating in the non-interrupt mode. Rapid readout of the buffer by the computer is necessary to prevent loss of data because when the buffer receives a new word, it wipes out the old word.

3.5.4 Writing Data Out of the Computer

Data write is a very simple operation. Assuming the write select line is always up, a sense pulse unique to the system being addressed should precede the rise of the channel ready write lines by at least four microseconds. The data lines and channel ready write signal will be directed by the buffer to the appropriate data system. The data demand pulse will come from the data system. The time delay in getting the data demand pulse back to the computer is therefore almost entirely dependent on the data system being addressed.

3.5.5 Clock Programing Requirements

The clock subsystem is a counting, parallel transfer register. It accepts data from Channel B and transfers it out on Channel C. When counting, the clock counts the computers AØD2 pulses. These pulses occur every machine cycle, which is 2.18 microseconds. The following are the signal

requirements for the clock subsystem:

For the computer to write into the register:

WRITE SELECT CHANNEL B
RESET AND LOAD CHANNEL B
CHANNEL C SENSE PULSE 3 (STORAGE POSITION 10) will read the 7090 word into the register, releasing the 7090 Channel B in about 25 microseconds. If the clock-register switch is in the clock position the counter will automatically start counting the AØD2 pulses. When the counter is full, i.e., when the sign bit changes, a master interrupt is generated and sense line 3 on Channel C will rise.

If the clock-register switch is in the register position, the register will load within 25 microseconds but will not count. It can be made to count in this mode by the Channel B sense pulse 10 (storage position 17).

In either the clock or register positions the count can be stopped at any time by the Channel B sense pulse 9 (storage position 16),
To read out the register contents:

READ SELECT CHANNEL C
RESET AND LOAD
CHANNEL C SENSE PULSE 3 (STORAGE POSITION 10) will initiate a readout cycle. This automatically stops any counting and allows fifty microseconds for carry propagation within the counter. A data demand pulse releases the computer within sixty microseconds after the sense pulse.

3.5.6 Restrictions

1. To prevent false trapping, the sign bit cannot be written by Channel C. Only thirty-five bits (1-35) can be addressed by Channel C. However, the sign bit can always be generated by allowing the system to count up to it.

2. In case other data is being read into the computer when the clock counter overflows, its interrupt will inhibited until the other record has been completely read out. In the case of DMS data this could be as much as 900 microseconds.

3.5.7 The inputs to the buffer are as follows:

DMS: Inputs data from FPS-16 Radar, Cotar and MTR
MicroSADIC: Inputs data from tapes
Teletype: Inputs teletype data
Paper Tape: Inputs data from paper tape } Through R. O. Subsystems
Radar Data Translator: }

3.5.8 The outputs are as follows:

Missile destruct signal and good-bad data signals } Through Point Mugu
Plotting board data } Computer Output System
Teletype information for transmission } Through R. O.
Paper tape information for later use } Subsystems
Range operations weather information }

3.5.9 READ SIGNALS

SIGNAL		FROM	REMARKS
READ SELECT		COMPUTER	Channel selected
CHANNEL READY READ		COMPUTER	Up for each word
RECORD CONTROL & WCØ		COMPUTER	Causes EOR
END OF RECORD		BUFFER	Marks blocks of data
INTERRUPT		BUFFER	Signal to look at sense lines
DATA DEMAND		BUFFER	Transfers data into 7090
SENSE OUTPUT RESET		COMPUTER	Resets sense pulse storage
SENSE PULSE	STG. POS		
1	8	COMPUTER	Transfer DMS record
2	9	COMPUTER	Transfer LOAC record
3	10	COMPUTER	Transfer clock word
4	11	COMPUTER	
5	12	COMPUTER	Transfer MicroSADIC word
6	13	COMPUTER	Transfer Range Op word
7	14	COMPUTER	Reserved for Range Op
8	15	COMPUTER	Reserved for Range Op
9	16	COMPUTER	Test all sense lines
10	17	COMPUTER	Sense data not wanted
SENSE LINE			
1	8	BUFFER	DMS record ready
2	9	BUFFER	LOAC record ready
3	10	BUFFER	CLOCK word ready
4	11	BUFFER	

SIGNAL		FROM	REMARKS
SENSE LINE	STG. POS		
5	12	BUFFER	MicroSADIC word ready
6	13	BUFFER	Range Op word ready — The R. O. systems use combinations of these three sense lines
7	14	BUFFER	
8	15	BUFFER	
9	16	BUFFER	NIKE-ZEUS liftoff
10	17	BUFFER	DMS lockout
WRITE SELECT		COMPUTER	Channel selected
CHANNEL READY WRITE		COMPUTER	Up for each word
DATA DEMAND		Data system via BUFFER*	Acknowledges receipt of data
INTERRUPT		Data system via BUFFER*	Used only by AAV to demand new data also available from output system
SENSE PULSE	STG. POS		
1	8	COMPUTER	Output system (PLOT) select
2	9	COMPUTER	Aircraft vectoring select
3	10	COMPUTER	Clock write select, clear & write in
4	11		
5	12		Reserved for Range Op
6	13	COMPUTER	Special output to Range Op
7	14		Reserved for Range Op
8	15		Reserved for Range Op
9	16	COMPUTER	Clock stop
10	17	COMPUTER	Clock start
RESET SENSE OUTPUT		COMPUTER	Required to clear sense pulse register

* Clock signals originate in buffer

4 REAL TIME INPUT RECORD

The computer input data appears in a record of thirty 24-bit words. The record is divided into five 6-word blocks devoted to timing, elevation angle, range, azimuth, and parity check. Each block is divided into six words. The information in this 30-word record is interleaved by input channel, such that the 5-word message from a source on channel 1 will appear in words 1 of all 5 blocks. The message from another source on channel 2 will appear in words 2 of all blocks, etc.

4.1 FPS-16 Radar Input Format

Input to the computer from the AN/FPS-16 radar appears in a five-word format of 24 bits per word. The usage of these words in the order of their appearance in Figure 5 is as follows:

Record Word 1	First Radar Word	Range Time
Record Word 7	Second Radar Word	Elevation Angle
Record Word 13	Third Radar Word	Slant Range
Record Word 19	Fourth Radar Word	Azimuth Angle
Record Word 25	Fifth Radar Word	Parity Check

4.1.1 Word 1 (First Radar Word)

The integer portion of the binary expression of range time appears as T in bits 21 through 35. The low order bit is 35 which represents two seconds as the finest time expression. The finer portion of the range time expression. The finer portion of the range time expression appears as T_{vn} in bits 14 through 20. These counts change at th rate of 40 counts per second and recycle every two seconds or 80 counts.

Annexing the counts of this, the vernier counter, to the course range time counter it becomes possible to sense range time to a fineness of 0.025 seconds. The vernier counter does not present a direct reading of the fine component of the time, however, since it does not register nor recycle at zero. Instead, the counter progresses to 80 and then returns to 1. It is, therefore, necessary to subtract a binary 1 from a readout of the vernier counter to obtain a reading of the fine component of range time.

The remaining bits, 12 and 13, of Word 1 are as shown in Figure 5 and are of no concern to the computer programing.

4.1.2 Word 7 (Second Radar Word)

This word receives the elevation angle E in bits 19 through 35. A readout of these bit positions results in the expression of a fraction of

WORD 1

12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
0	X	T_{V_7}	T_{V_6}	T_{V_5}	T_{V_4}	T_{V_3}	T_{V_2}	T_{V_1}	T_{15}	T_{14}	T_{13}	T_{12}	T_{11}	T_{10}	T_9	T_8	T_7	T_6	T_5	T_4	T_3	T_2	T_1

WORD 7

0	0	$\bar{O}$	I_3^0	I_2^0	I_1^0	0	E_{17}	E_{16}	E_{15}	E_{14}	E_{13}	E_{12}	E_{11}	E_{10}	E_9	E_8	E_7	E_6	E_5	E_4	E_3	E_2	E_1

WORD 13

0	0	R_{22}	R_{21}	R_{20}	R_{19}	R_{18}	R_{17}	R_{16}	R_{15}	R_{14}	R_{13}	R_{12}	R_{11}	R_{10}	R_9	R_8	R_7	R_6	R_5	R_4	R_3	R_2	R_1

WORD 19

0	0	I_3^1	I_2^1	I_1^1	I_3	0	A_{17}	A_{16}	A_{15}	A_{14}	A_{13}	A_{12}	A_{11}	A_{10}	A_9	A_8	A_7	A_6	A_5	A_4	A_3	A_2	A_1

WORD 25

P_{BD}	0	$P_{CH}2$ O	I_2^2	I_1^2	X	$P_{CH}2$ E	$P_{CH}3$ O	$P_{CH}4$ O	X	$P_{CH}1$ O	I_2^3	I_1^3	$P_{CH}1$ E	$P_{CH}3$ E	$P_{CH}4$ E	0	0	0	0	X	T_{V_7}	T_{V_6}	T_{V_5}

LEGEND

A	Azimuth	P_{CH}	Parity (Longitudinal)
E	Elevation	T_n	Time (PMR Range)
I^O_n	Identification	T_{Vn}	Time (Vernier Count)
$\bar{O}$	On Target	X	Constant "One" Bits
P_{BD}	Parity (Bad Data)	0	Constant "Zero" Bits

Figure 5. AN/FPS-16 Radar Input Format

a circle. The value associated with each bit, beginning with the high order bit 19, is:

$$\pi/2^0, \quad \pi/2^1, \quad \pi/2^2, \quad \cdots \quad \pi/2^{16}.$$

Bit 14 in this word displays a 0 when the radar is off track and a 1 when the radar is on track. The other bit positions are of no concern to the computer programing.

4.1.3 Word 13 (Third Radar Word)

This word expresses range in yards using bit positions 14 through 35, The low order bit 35, identified as R_1, has the value of 0.5 yards. The series R_1 through R_{21} is associated with the values:

$$2^{-1}, 2^0, 2^1, \cdots, 2^{19}.$$

Other bits in this word are unrelated to the computer programing.

4.1.4 Word 19 (Fourth Radar Word)

This word is devoted to the expression of azimuth angles. It is used and described in the same as Word 7 except for bit 14 which has no use in this word.

4.1.5 Word 25 (Fifth Radar Word)

The only part of this word used in the computer processing of the data is the bit appearing in position 12 labeled P_{BD}. This is a parity bit and is interpreted thus:

1	Bad data
0	Good data.

4.2 Cotar Input Format

Input to the computer from the Cotar appears in a five-word format of 24 bits per word. The usage of these words in the order of their appearance in the record and in Figure 6 is as follows:

Record Word 2	First Cotar Word	Range Time
Record Word 8	Second Cotar Word	Frequency Corrections
Record Word 14	Third Cotar Word	Cosine β
Record Word 20	Fourth Cotar Word	Cosine α
Record Word 26	Fifth Cotar Word	Parity Check

4.2.1 Word 2 (First Cotar Word)

This word receives the range timing information associated with the Cotar data in a manner exactly the same as Word 1. For details, refer to Word 1 under FPS-16 Radar Input.

	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
WORD 2	0	X	T_{V_7}	T_{V_6}	T_{V_5}	T_{V_4}	T_{V_3}	T_{V_2}	T_{V_1}	T_{15}	T_{14}	T_{13}	T_{12}	T_{11}	T_{10}	T_9	T_8	T_7	T_6	T_5	T_4	T_3	T_2	T_1
											K_R					K_C								
WORD 8	0	0	Q	I	I	I	I	I	I	I	A_{14}	A_{13}	A_{12}	A_{11}	A_{10}	A_9	A_8	A_7	A_6	A_5	A_4	A_3	A_2	A_1
							cos 1 β																	
WORD 14	0	0	I	I	I	B_{19}	B_{18}	B_{17}	B_{16}	B_{15}	B_{14}	B_{13}	B_{12}	B_{11}	B_{10}	B_9	B_8	B_7	B_6	B_5	B_4	B_3	B_2	B_1
							cos 2 α																	
WORD 20	0	0	I	I	I	C_{19}	C_{18}	C_{17}	C_{16}	C_{15}	C_{14}	C_{13}	C_{12}	C_{11}	C_{10}	C_9	C_8	C_7	C_6	C_5	C_4	C_3	C_2	C_1
WORD 26	P_{BD}	0	$P_{CH}2$ O	I	I	X	$P_{CH}2$ E	$P_{CH}3$ O	$P_{CH}4$ O	X	$P_{CH}1$ O	I	I	$P_{CH}1$ E	$P_{CH}3$ E	$P_{CH}4$ E	0	0	0	0	X	T_{V_7}	T_{V_6}	T_{V_5}

LEGEND

Q_O	Data Quality	T_N	Time (PMR Range)
I_N	Identification Octal Code	T_{V_N}	Time (Vernier Count)
A_N	Data Parameter	X	Constant "One" Bit
B_N	Cosine 1 (β)	0	Constant "Zero" Bit
C_N	Cosine 2 (α)	P_{CH}	Longitudinal Parity
P_{BD}	Parity (Bad Data)		

Figure 6. Cotar Input Format

4.2.2 Word 8 (Second Cotar Word)

This word contains three unrelated groups of data identified as K_r, K_c and Q. K_r is a constant, K_c is a variable factor, and Q a quality bit.

4.2.2.1 K_r, Transmitter Constant

There exists in the system a Cotar frequency correction term K_r. This correction represents the magnitude of the transmitter frequency deviation from the Cotar design frequency f_b. The value of K_r in megacycles is not transmitted, but is tabled in the computer opposite a set of code numbers as arguments. The term is constant for any transmitter frequency and is introduced by a code, set in bit positions 22 through 26, noted A_{10} through A_{14}. This code is the argument for the table lookup to obtain K_r.

4.2.2.2 K_c, Doppler Compensation

The Doppler effect is measured by the Cotar and expressed as single cycles per second. The output of this measuring device appears as a whole number in bit positions 27 through 35, labled A_1 through A_9.

4.2.2.3 Q, Data Quality

Position 14, labeled Q is a quality bit. This is the output of a device in the Cotar that compares the signal received with a standard determined by the setting of K_r. Bit 14 displays a 1 if the comparison is favorable and a 0 if it is unfavorable. Criteria for making the distinction is a Cotar matter and of no concern to the program. The program accepts or rejects on the basis of this bit, however.

4.2.3 Word 14 (Third Cotar Word)

The binary representation of a number that is proportional to the direction cosine β or its complement appears in bit positions 18 through 35, labeled B_1 through B_{18}. Position 17 is a sign bit. If this bit is 0, the contents of positions 18 through 35 are interpreted as proportional to the direction cosine β with a negative sign. If bit 17 is 1, the contents of these positions are interpreted as proportional to the positive one's complement of the direction cosine β. This information is the output from a set of code wheels. The required function is the product of this output multiplied by an instrument constant.

4.2.4 Word 20 (Fourth Cotar Word)

This word is used exactly the same as Word 14 above except the angle α is processed instead of β.

4.2.5 Word 26 (Fifth Cotar Word)

This word is used for the Cotar input in exactly the same manner as Word 25 serves the FPS-16 Radar Input.

4.3 Missile Tracking Radar Input Format

Input to the computer from the Missile Tracking Radar (MTR) appears in a five-word format of 24 bits per word. The usage of these words in the order of their appearance in Figure 7 is as follows:

Record Word 3	First MTR Word	Range Time
Record Word 9	Second MTR Word	Elevation Angle
Record Word 15	Third MTR Word	Slant Range
Record Word 21	Fourth MTR Word	Azimuth Angle
Record Word 27	Fifth MTR Word	Parity Check

4.3.1 Word 3 (First MTR Word)

This word receives the range timing information associated with the MTR data in a manner exactly the same as in Word 1. For details, refer to Word 1 under FPS-16 Radar Input.

4.3.2 Word 9 (Second MTR Word)

This word receives the elevation angle E in bits 18 through 35. A readout of these bit positions results in the expression of a fraction of a circle. The value associated with each bit, beginning with the high order bit 18, is:

$$\pi/2^0, \ \pi/2^1, \ \pi/2^2, \ \cdots, \ \pi/2^{17}.$$

Bit position 14, labeled B, signals lift-off in addition to on and off track. Initially the position is inactive. At lift-off the position displays a 1. Thereafter, throughout the operation, this bit is interpreted as follows:

0 Off Track
1 On Track

The computer program is concerned with no other bits in this word.

4.3.3 Word 15 (Third MTR Word)

The major use of Word 15 is to receive slant range. The low order bit in bit position 35 as received has the value .09367972 meters which is treated in the program as .30743815 feet. The range is thus treated in these terms with bit position 15 noted R_{B1} as the high order bit.

The MTR samples at a rate of 8.123 samples per second but the program is designed for a sampling rate of twenty samples per second. In order that it process only new data it will test on bit position 14, labeled R_{B2}. A new data sample will introduce a 1 in this position which will change to a 0 when the sample has been processed.

No other parts of this word concern the computer program.

4.3.4 Word 21 (Fourth MTR Word)

This word receives the azimuth angle and is the same as Word 9 except that bit 14 is unassigned. For details beyond this exception, refer to Word 9 of this section.

Word	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
WORD 3	0	X	T_{V_7}	T_{V_6}	T_{V_5}	T_{V_4}	T_{V_3}	T_{V_2}	T_{V_1}	T_{15}	T_{14}	T_{13}	T_{12}	T_{11}	T_{10}	T_9	T_8	T_7	T_6	T_5	T_4	T_3	T_2	T_1
WORD 9	0	0	$\bar{0}$	I_3^0	I_2^0	I_1^0	E_{18}	E_{17}	E_{16}	E_{15}	E_{14}	E_{13}	E_{12}	E_{11}	E_{10}	E_9	E_8	E_7	E_6	E_5	E_4	E_3	E_2	E_1
WORD 15	0	0	R_{22}	R_{21}	R_{20}	R_{19}	R_{18}	R_{17}	R_{16}	R_{15}	R_{14}	R_{13}	R_{12}	R_{11}	R_{10}	R_9	R_8	R_7	R_6	R_5	R_4	R_3	R_2	R_1
WORD 21	0	0	I_3^1	I_2^1	I_1^1	I_3	A_{18}	A_{17}	A_{16}	A_{15}	A_{14}	A_{13}	A_{12}	A_{11}	A_{10}	A_9	A_8	A_7	A_6	A_5	A_4	A_3	A_2	A_1
WORD 27	P_{BD}	0	$P_{CH}2_O$	I_2^2	I_1^2	X	$P_{CH}2_E$	$P_{CH}3_O$	$P_{CH}4_O$	X	$P_{CH}1_O$	I_2^3	I_1^3	$P_{CH}1_E$	$P_{CH}3_E$	$P_{CH}4_E$	0	0	0	0	X	T_{V_7}	T_{V_6}	T_{V_5}

LEGEND

A	Azimuth	P_{CH}	Parity (Longitudinal)
E	Elevation	T_N	Time (PMR Range)
I^O_n	Identification(Octal Code)	T_{VN}	Time (Vernier Count)
$\bar{0}$	On Target	X	Constant "One" Bits
P_{BD}	Parity (Bad Data)	0	Constant "Zero" Bits

Figure 7. Missile Tracking Radar Input Format

4.3.5 Word 27 (Fifth MTR Word)

This word is used for the MTR input in exactly the same manner as Word 25 serves the Radar Input.

5 AUTHORITIES ON INDIVIDUAL SYSTEMS

For more detailed information on individual systems refer to following authorities.

Computer Buffer System	B. Larey or C. LeRoy	Code 3162
DMS	A. James	Code 3286
MicroSADIC	J. Kendrick	Code 3286
Computer Output System	B. Larey	Code 3162
Teletype	J. Falkner	Code 3286
R. O. Subsystems	J. Falkner	Code 3286
Radar Data Translator	J. P. Harvey	Code 3286
IBM Handling of Live Data	IBM Manual No. L22-6537	

AD- Div. 15

Land-Air, Inc., Point Mugu, Calif.
THE PMR REAL TIME DATA PROCESSING SYSTEM by R. Johnson, ed. by T. Wakai, an introduction to. 31 Oct. 62. 23 p, incl. illustrations. (Report No. 37) (Contract N-123(61756)19425A/PMR) Unclassified report

This overview of the PMR Real Time Data Processing System explains the scope and function of the system. The document includes (1) a block diagram of the flow of information to the PMR Digital Data System, (2) the programing requirements for the Larey-LeRoy Computer Buffer System, (3) a list of people who may be contacted for additional information on the individual subsystems, and (4) a brief description of the following: (a) AN/FPS-16 radar, (b) Missile Tracking Radar, (c) Cotar, (d) Digital Distribution Unit, (e) Speed Changer and Buffer, (f) Collins TE-206 Kineplex Transmitter and Receiver, (g) Data Multiplexing Synchronizer, (h) MicroSADIC and DOLAR Systems, (i) Teletype, (j) Paper Tape, (k) Larey-LeRoy Computer Buffer System, (l) Real Time Input Record.

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1. Impact Computer
2. Mathematical Computers -
   Control System
   Digital System
3. Mathematical Computer Data -
   Processing
   Storage
4. Data Transmission
5. Programing
6. Radar Ranging System
7. Cotar
8. Buffer-Computer
9. Real Time-Data Processing

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1. Impact Computer
2. Mathematical Computers -
   Control System
   Digital System
3. Mathematical Computer Data -
   Processing
   Storage
4. Data Transmission
5. Programing
6. Radar Ranging System
7. Cotar
8. Buffer-Computer
9. Real Time-Data Processing

I. Johnson, R. and T. Wakai
II. Pacific Missile Range
III. Contract N-123(61756) 19425A/PMR

Armed Services
Technical Information Agency

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